SKIDOO MINE
Death Valley National Park
Park Route 38 (Skidoo Road)
Death Valley
Inyo County
California

HAER No. CA-290

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HISTORIC AMERICAN ENGINEERING RECORD
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HISTORIC AMERICAN ENGINEERING RECORD

SKIDOO MINE

Death Valley National Park, California HAER No. CA-290

Location:	The Skidoo Mine is located on the west side of the Panamint Range near its northern terminus in Inyo County, California.
Date of Construction:	1907-1908
Present Owner:	Department of the Interior, National Park Service
Present Use:	Non-interpreted site in Death Valley National Park
Significance:	The Skidoo Mill is associated with the operations of the Skidoo Mines Company, Death Valley's most successful gold mine. Although the mill shows structural deterioration, the mill is otherwise a well-preserved example of the California Gold Mill, an ore processing system once employed ubiquitously throughout Western gold fields during the nineteenth and early twentieth centuries.
Historian:	Paul J. White
Project Information:	The Skidoo Mill was recorded as part of an initiative by the Historic American Engineering Record (HAER) to document North America's hard-rock mining heritage. HAER recorded the mill structure during the summers of 2000 and 2001, with funding provided by Death Valley National Park (DEVA) and HAER. The recording team consisted of architects Arin Streeter, Cristy Fletcher, Nancy Hung, and Johnny Yu, with large-format photography conducted by Gianfranco Archimede (Michigan Technological University). Richard O'Connor, Senior Historian at HAER, supervised the project.

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INTRODUCTION

Today's traveler to the Skidoo Mines, a place once titled "the Queen of the Panamints,"[1] might easily drive past the turnoff. From a route that negotiates Emigrant Canyon on the west side of the Panamint Mountains an unpretentious dirt road leads eastward into the sagebrush with little indication of a rationale. At the road's terminus, however, upon a high plateau 5,700 feet above sea level (and 5,982 feet above the floor of neighboring Death Valley), are abundant signs of mining activity dating from the 1900s to 1970s. Flanking a former town site are mine workings that extend northwesterly for nearly two miles in length and one-quarter of a mile in width. In addition to building foundations, ore bins, and trail networks, surface features include over 30 adits (tunnels), 50 shafts, and in excess of 100 prospect sites alongside their associated spoil piles.[2] On the south side of a narrow ravine west of "town" is an exception to the general absence of standing structures--a six-level gold milling facility missing a roof and some walls, but for the most part, complete in its internal circuitry.

These remnants provide a local example of a larger pattern of precious-metal mining that began with the discovery of gold deposits in mid-nineteenth century California and spread eventually throughout most states west of the Mississippi. As the West's earliest extractive industry to be conducted at an intensive scale, metal mining brought widespread population shifts and major landscape transformations. With the course of 150 years, the once prevalent traces of gold mining have faded to place names, settlement patterns, and transportation networks. Direct reminders can, however, still be found in less populated regions, such as southeastern California, where current, mothballed, and forsaken mining ventures remain conspicuous.

In comparison with the history of gold mining in California, Skidoo was a late bloomer. Its ore deposits were discovered around the turn of the twentieth century, and the mines would see intermittent work over the next seventy years. Within this period, Skidoo became Death Valley's most productive gold operation, and historically the only gold mine in the region

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[1] *Rhyolite Herald*, Pictorial Supplement, 1908.

to pay dividends. In common with the majority of lode-mines, both in the general vicinity and throughout the West, mining activity at Skidoo also involved the construction of a milling facility to process ores onsite. In design and implementation, the Skidoo mill operated from principles that had arisen from fifty years of experience on California's gold fields. By the mid-twentieth century, however, gold mining and milling had undergone significant revisions. This account of Death Valley's golden matriarch centers on the history of the mill, the mine's most notable enduring feature. In addition to documenting events leading to its construction, the mill is also viewed in terms of its changing association with the traditions and transformations of California's gold mining industry.

LODE-GOLD MINING IN CALIFORNIA TO 1906

When John Ramsey and John Thompson discovered the Skidoo ore deposit upon a high ridge in the Panamints in 1906, California's prospectors were well accustomed to seeking gold in "them thar hills." The rich placer deposits (typically river gravels) that had lured the 1849 rushers were largely exhausted by the mid-1860s, and while gold was still present, it was increasingly harder for miners to win profits using the panning methods that had prevailed earlier.[3] Indeed, many prospectors had already left California to follow discovery stampedes throughout the west, including to Nevada (1859), Colorado (1859), British Columbia (1861) and, to a lesser extent, to strikes overseas (including New South Wales (Australia) and New Zealand). Placer mining outfits that now profited in California were backed by considerable capital and used technologies capable of attaining greater economies of scale. "Hydraulicking," a technique that used pressurized jets of water to excavate riverbanks, became widespread in the working of placers

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[2] U.S. Geological Survey, "Emigrant Canyon, Quadrangle," and "Tucki Wash Quadrangle" provisional edition topographic maps (U.S. Geological Survey, 1986).
[3] Main events and trends in California's gold production are usefully itemized in William B. Clark, "Gold Districts of California," *California Division of Mines and Geology Bulletin 193* (San Francisco: California Division of Mines and Geology, 1970), Table 2.

from the 1870s until the mid-1880s, and dredges worked the lower reaches of watersheds by the turn of the century.[4]

The general demise of rich placer ground also spurred miners to prospect for gold-bearing veins. Lode deposits, from which placers originated, were formed by the filling of mineralized material into fissures in country rock. Depending on the formation environment, veins could be tabular in shape (long in two dimensions and short in the third), or less well defined as stringers and erratic lenses.[5] Gold was typically found within quartz veins, and in distribution, could be fairly homogeneous across the vein, or concentrated at the interface between the quartz and "host" rock. Veins first mined in the nineteenth century contained fine-to-coarse sized gold particles visible to the eye. These ores were high in "free gold" (gold uncombined with other substances), although sulfides which bound intimately with gold were almost always present.

In California, gold deposits were distributed in two broad belts. The westernmost, of Cretaceous age (70-135 million years ago), began close to the southern extent of the state and swept northwards along the spine of the Sierra Nevada Range, turning slightly northwest toward the Oregon border. Most ores were found among slates and altered volcanic rocks. A secondary

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[4] Hydraulicking declined rapidly following Judge Lorenzo Sawyer's 1884 ruling against hydraulic mining in the Woodruff vs. North Bloomfield Gravel Mining Company case. For general overviews of the transformations in California mining practices, refer Rodman W. Paul, *California Gold: The Beginning of Mining in the Far West* (Cambridge: Harvard Univ. Press, 1947); Otis E. Young, *Western Mining: An Informal Account of Precious-Metals Prospecting, Placering, Lode Mining, and Milling on the American Frontier from Spanish Times to 1893* (Norman, Oklahoma, Univ. of Oklahoma Press); James Rawls and Richard Orsi (eds.), *A Golden State: Mining and Economic Development in Gold Rush California* (Berkeley: Univ. of California Press, 1999).
[5] Bureau of Mines, *A Dictionary of Mining, Mineral, and Related Terms* (Washington D.C.: GPO, 1968). Charles Jackson and John Knaebel, "Gold Mining and Milling in the United States and Canada: Current Practices and Costs," *U.S. Geological Survey Bulletin 363* (Washington D.C.:GPO, 1932), 13-20. The average concentration of gold in the earth's crust is approximately 0.004 parts per million Today, mines can profitably work ores from 250 to 5,000 times above the average [Joseph Cornellisson, *An Economic Analysis of Small-Scale Mining Operations*, MS thesis (Golden Colorado, 1984), 27], well improved from what constituted a workable ore in the nineteenth century.

belt, of Tertiary age (1-70 million years ago), extended along the eastern portion of the state, with outcroppings occurring in andesites and rhyolites.[6]

Prospectors initially searched for gold veins in established placer districts. If an outcrop was not immediately visible, miners systematically tested slide debris uphill and upstream from placers, digging a trench at the point where no further gold flecks were panned.[7] Following discovery, prospectors assessed the physical and chemical characteristics of the ore body as well as the host rock. External conditions, such as regional infrastructure and anticipated scale of operation were also important in these assessments, for the value of an outcrop and its determination as an "ore" hinged not on the amount of gold present, but whether the vein could be worked at a profit. If suitable capital was available and an outcrop was deemed economically viable (or if discouraging conditions were ignored), the lode next underwent "development." This involved the driving of tunnels and shafts to access and define the ore body. Once an ore was blocked out a mine entered the extraction phase, in which the ore was removed. Lode mines typically conducted prospecting, development, and extraction activities simultaneously. In this way, proceeds from extraction paid for investigatory work. Nevertheless, the lengthy duration it often took for a mine to first enter production (i.e., extraction) meant that lode mining demanded considerable start-up finances.

Lode mining in California began as early as 1849 with the discovery of quartz veins at Mariposa. Amid the speculation of lode properties that ensued, many early mines were operated by companies largely unfamiliar with California ores and hard-rock mining in general. Machinery imported to the mines was in some cases of untested design and in others relatively ineffective because of a lack in suitably skilled labor. Although interest in lode mining had slumped in 1853, lode mining showed signs of revival and increasing professionalization by the end of the decade.[8] Thirty-five lode

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[6] Waldemar Lindgren, "The Geological Features of the Gold Production of North America," in *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 33 (1903), 816.
[7] Jackson and Knaebel, "Gold Mining and Milling," 36-7.
[8] The improved professionalization included the greater employment Cornishmen, who in the nineteenth-century were considered experts in underground work. See John Rowe, *The Hard-Rock Men: Cornish Immigrants and the North American Mining Frontier* (Harper & Row, 1974), 96-126; Paul, *California Gold*, 130-1.

mines operated in California in 1855. By 1857, this number had quadrupled, and a little more than a decade later, lode mining accounted for 31 percent of the value of all gold mined in the state.[9] As with placer deposits, the most productive mines were located on the "Mother Lode," a region occupying the northern and central portions of the state along the Sierra Range.

Precious-metal mining along the eastern edge of the state occurred principally after the discovery of Nevada's Comstock Lode in 1859. Subsequent prospecting between the California and Nevada districts identified high-grade silver and gold deposits, albeit generally more complex in chemistry than the ores exploited in the Sierras. Death Valley received some attention by miners at this time, although it yielded almost no rewards (except in the mining of borax, a salt occurring naturally on the valley floor). During the 1860s, several dozen prospectors looked fruitlessly for the "Lost Breyfogle Mine," while some modest gold prospects were developed around Gold Mountain, northeast of the valley. In the 1870s, a short-lived rush occurred around the discovery of a silver outcrop in Surprise Canyon in the Panamint Range, some 20 miles south of the future site of Skidoo.[10] Gold mining, however, did not fully commence in the Panamints until the turn of the twentieth century, when prospectors scoured the region on the news of rich strikes in the Funeral Range (Death Valley's eastern border) and neighboring Amargosa Valley. Within a few years, development work occurred at Skidoo, the Cashier Mine in Harrisburg, and in Trail Canyon (respectively five and ten miles southeast of Skidoo).

Gold mining in Death Valley occurred under difficult circumstances, for not only did the area remain peripheral to mining centers, but arid conditions and moderate-to-low ore values were not particularly conducive to winning profits by the small enterprises that tended to work them. Nevertheless, mining as an industry was adaptable to working in remote locations. To combat elevated overheads, mine operators typically

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[9] Paul, *California Gold*, 130-1, 143-4; Daniel Cornford, "'We All Live More Like Brutes than Humans': Labor and Capital in the Gold Rush," in *A Golden State*, 94-95.

[10] Refer H. H. Taft, "Notes on Southern Nevada and Inyo County, California," in *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 37 (1907), 194; Richard Lingenfelter, *Death Valley and the Amargosa: A Land of Illusion* (Berkeley: Univ. of California Press, 1986), 113-134.

concentrated ore values by two methods. Underground, workers selectively mined the highest-grade possible to maximize values per ton, while on the surface, ores were reduced further by milling (also termed "ore dressing" and "beneficiation").

For gold and silver mining, onsite milling was especially advantageous because these metals had high monetary value, were often located in "remote and inhospitable regions," and could be reduced to bullion by relatively simple processes.[11] As a result, gold mining operators tended to construct milling facilities earlier in property development than in the mining of base metals--a decision that did not always meet the approval of mining geologists who encouraged the careful characterization of ores.[12] Although mining engineers did not consider milling plants pivotal to mining operations, once constructed, most conceded that a mill's efficient and economic performance was critical to the success of the venture as a whole.[13]

MILLING PRINCIPLES AND CALIFORNIA PRACTICE

Information on milling techniques at local, regional, and national scales is, as a matter of circumstance, often better preserved in documentary materials than information about the mining operations that brought them into being. Because milling performance was so intimately connected with a mine's profits, descriptions of the milling plant often formed a sizable part of mine reports to government agencies. Mining journals frequently published mill flow sheets and article-length descriptions of mill operations with the intent of distributing knowledge about improvements to milling economy and efficiency. Possibly because mills served as a tangible (albeit falsifiable) indicator of mine investment and growth, milling activities also received considerable coverage in local newspapers.

At an elementary level, the milling process involves stages of crushing, in which ore is reduced to a size where valued products are more

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[11] Charles. Jackson and J. H. Hedges, "Metal-Mining Practice" *U.S. Bureau of Mines Bulletin 419* (Washington D.C.:GPO, 1939), 391.
[12] Jackson and Knaebel. "Gold Mining and Milling," 68; Jackson and Hedges, "Metal-Mining Practice," 385.
[13] Jackson and Knaebel, "Gold Mining and Milling," 68.

easily recoverable, and concentration, where the desired material is separated from waste rock (gangue). The typical nineteenth-century milling circuit accomplished the first task by passing ore through several machines arranged in series. Engineers categorized crushing equipment into two types: rock breakers, which crushed the ore as received from the mine to approximately one-quarter inch in diameter; and fine crushers, which reduced the broken ore further to "milling size," generally, a coarse sand or finer.

For the concentration stage, three methods--amalgamation, gravity concentration, and cyanidation--found common employment in nineteenth and twentieth century gold mills.[14] Each method required specialized equipment, although some machines (such as classifiers, which sorted ore according to size and/or density, and dewaterers for thickening pulp) could supplement more than one method by standardizing feed and improving overall extractive efficiency.

The amalgamation process extracted gold chemically by introducing mercury to crushed ore. The contact of free gold and mercury formed a "pasty" amalgam, an alloy containing approximately one-third gold by weight. Millwrights recovered the alloy from the rest of the material by dressing the mercury to a fixed metal surface (typically a copper plate), on which the amalgam accumulated. Amalgamation machines later supplemented "plate" amalgamation techniques. While designs varied, amalgamator devices brought water, mercury, and ore together under turbulence. A simpler method involved the direct addition of mercury and water into crushing machinery. Amalgam recovered from plates and milling equipment was refined back to its constituent parts by retorting, often in a mine's assaying facility.

Gravity concentration separated mineral grains according to differences in specific gravity. In practice, most methods sorted particles by relative weight, with their specific gravity approximated by the maintenance of a uniform feed size. Jigs, for instance, sorted material in a pattern similar to fluvial deposits. Ore was introduced into a water trough equipped with a shaking bed. The oscillation of the bottom grate graded the feed, with

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[14] A fourth concentration method known as the chlorination or Plattner process dissolved gold using chlorine gas. This technique found use in a number of early nineteenth-century California gold mills, but by the late nineteenth century was superceded by cyanidation.

heavier particles (including metals or metal-rich minerals) resting on the bottom. Vanners sorted particles by washing material across an oscillating, continuous rubber belt. Light particles flowed off one end of the vanner, while heavier material traveled up the belt and fell off the opposite end of the machine. Shaking tables, which employed similar principles as the vanner, shook ore over a slightly inclined tabletop fitted with riffles (wooden slats). Heavier particles caught against the riffles and were shaken by the table's motion to one end of the table to be bagged as concentrate. Lighter minerals, such as the host rock, flowed over the riffles and off the table. A later and altogether different form of gravity concentration involved the addition of reagents (such as oil and creosote) into a water bath. These ingredients decreased the specific gravity of selected minerals, which, in combination with turbulence, caused fine metal particles to adhere to air bubbles on the surface. This "flotation" technique was first used by modern industry in the 1870s, but patent disputes prevented its widespread application in mineral processing until the 1920s.

Cyanidation recovered gold by its solubility in potassium- or sodium cyanide solutions. Early cyanidation circuits worked best with sand-size particles, and slimes (silt-sized particles and smaller) were often discarded before processing. In general operation, a cyanide mixture was introduced to milled ore in a settling tank, which dissolved the gold and other metallic minerals into solution over a period of several days. The "pregnant"(metal-rich) solution was then siphoned from the tanks and precipitated using zinc or aluminum dust. This took place in either a filter press, where the pregnant solution and zinc dust were pumped through a series of plate or frame filters, or in a precipitation tank, a long metal box divided into several compartments in which zinc shavings were piled. Precipitate recovered from either method could then be shipped as concentrate to a smelter, or refined to bullion on site.[15]

The concentration method selected for a mill rested heavily on the character of the ore and available finances. Amalgamation, for instance, was fairly inexpensive for free gold ores, but the presence of sulfides tended to "sicken" mercury and reduce its effect. Gravity concentration could also be rendered ineffective if density differences between ore and gangue became less pronounced, as tended to happen with increased chemical complexity. Cyanidation ranked among the most expensive concentration methods, but often worked as a "catch-all" method for treating gold ores. Nevertheless, the presence of some metallic oxides, carbonates, hydrates, sulfates, arsenates, and soluble sulfides were known to attack cyanide salts and reduce extractive efficiency. In the experience of most mines, ores represented a combination of mineral types and chemical complexity tended to increase with depth. Consequently, if finances were available, it was judicious for a mill to treat ore by more than one process. The most frequent combinations in nineteenth and early-twentieth century mills included amalgamation and gravity concentration, and amalgamation and cyanidation.[16]

Practices at neighboring mines also influenced the selection of milling methods. In addition to common formation and weathering histories, mining districts often shared technical expertise directly through the circulation of skilled tradesmen, formation of "discussion clubs," and, less personably, by articles in trade journals and newspapers.[17] Such reasons were likely responsible for the diffusion of a blueprint for gold beneficiation during the mid-to-late-nineteenth century that came to be known as the "California Gold Mill."[18] The first California Mills were developed by gold operations in the 1850s. By the 1870 census, 413 such mills were recorded to be in existence in the state.[19]

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[15] For the design of cyanidation circuits, refer: James Dorr, *Cyanidation and Concentration of Gold and Silver Ores* (New York: McGraw-Hill, 1936); E. M. Hamilton, *Manual of Cyanidation* (New York: McGraw-Hill, 1920).

[16] The utility of amalgamation relates in part to free gold accounting for the majority of gold ores worked into the 1920s. Arthur Taggart, *Handbook of Ore Dressing* (London: John Wiley and Sons, Inc., 1927), 122.

[17] The first discussion club in California began in Grass Valley in 1855, "in order to facilitate the exchange of ideas relating to lode mines." Paul, *California Gold*, 258. The *Rhyolite Daily Herald* published principles of stamp milling over several installments in November 1907.

[18] Ed. B. Preston, *California Gold Mill Practices*, California State Mining Bureau Bulletin No. 6 (Sacramento: A. J. Johnston, 1895).

[19] Rossiler W. Raymond. *Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains* (Washington D.C.:GPO, 1873), 462-469.

In the typical California Mill, a jaw crusher performed the first task of breaking rock received from the mine.[20] This device pushed a movable plate towards a fixed plate, with ore introduced between the two plates. The repetition of this action broke the ore until it could pass through a gap maintained between the plates.

The distinguishing element of the California Mill, however, centered on the fine crushing stage, and specifically, upon select modifications to the gravity stamp. This tried-and-true device, known to have been in use by the fifteenth century, crushed ore by the raising and dropping of heavy rods (stems) in a manner similar to a mortar and pestle.[21] The raising motion happened mechanically by the action of cams fixed to a rotating shaft. As the cam rotated, the arm of the cam caught the lower edge of a tappet (a large metal collar) and raised the stem. As soon as the arm rotated beyond the lip of the tappet, the stamp dropped by gravity into a mortar box where the ore was distributed. In its usage in Cornwall, each stem--approximately four inches square and 10 feet high--dropped from 60 to 80 times per minute. To prevent the bunching of ore in the mortar (which decreased crushing efficiency and led to uneven wear), each stem was arranged to drop as its neighbors rose. Screens attached to the front of the mortar regulated the size of crushed material (most commonly a coarse sand) discharged from the stamps.

Californian modifications to the stamp included a sturdier frame construction, which enabled operators to increase the weight of individual stamps and the drop rate from 90 to 100 drops per minute.[22] The typical Californian stamp used metal stamp components supported by a wooden frame. The positioning of cams to one side of round stems rotated the stem slightly

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[20] By the last quarter of the nineteenth century, the jaw crusher had replaced sledge-hammering as the initial rock breaker throughout the western gold fields. Jaw crushers remained a popular crushing device through much of the twentieth-century, with most improvements in handling capacity brought about by increases in the machine's size. Refer Arthur Taggart, "Seventy-five Years of Progress in Ore Dressing," in A. B. Parsons (ed.), *Seventy-five Years of Progress in the Mineral Industry* (New York: American Institute of Mining and Metallurgical Engineers, 1947), 91.
[21] See, for instance, Georgius Agricola, *De Re Metallica*, translated by Herbert C. Hoover, and Lou H. Hoover (New York: Dover Publications, 1950).
[22] Robert Lescohier, *The Stamp Mill for the Recovery of Gold from Hard Rock* (privately published, 1991), 8-27.

with each drop, giving a more uniform wear on components. Improvements in performance also extended to mechanizing the flow of ore into the mortar and modifying the stamp drop order. Two drop sequences with wide acceptance by the early twentieth-century included the "California" pattern, with stamps falling on the order of 1, 4, 2, 3, 5 (numbering stamps from the pulley end) and the "Homestake" (originating from the Homestake Mine, South Dakota) which used a 1, 3, 5, 2, 4 sequence. A greater variety of patterns (including reverse California and Homestake sequences, respectively 1, 5, 2, 4, 3, and 1, 4, 2, 5, 3) nevertheless existed because millwrights contended different sequences gave different efficiencies.[23] Regional differences were also seen in the regulation of drop height and drop rates. Mills in Colorado, for instance, typically operated at slower speeds (approximately 30 drops per minute) with a drop height of 18-20 inches, increased the from the 4-6 inches commonly used in California mills.[24]

The most significant improvement to the stamp, however, was its utilization as an amalgamation device. By the 1880s, the inclusion of mercury-dressed copper plates in the interior of the stamp mortar (in addition to similar "apron" plates set in front of the stamp mortar) had doubled gold recovery rates to 60-80 percent, and made gravity stamps particularly economical for gold operations in remote districts.[25] The efficiency of aprons was also improved by increasing the table width and decreasing the gradient.[26]

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[23] The only combination possible if no adjacent stamps dropped consecutively is 1, 3, 5, 2, 4, and its reverse pattern, 1, 4, 2, 5, 3. W. J. Sharwood, "Hydrometallurgy of Gold and Silver," in Donald Liddell (ed.) *Handbook of Non-Ferrous Metallurgy*, Vol. II (McGraw-Hill: New York, 1926), 1012.
[24] The "Colorado Mill" otherwise derived from the California Mill. T. A. Rickard, "The Limitations of the Gold Stamp Mill," in *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 23 (1894), 138.
[25] Stamp battery plates were later discouraged because the jostled movements of sands in the mortar increased the wear of plates and scraped off much of the amalgam. The plates additionally reduced the size of the mortar box, which impacted the stamp's daily capacity. Refer: Thomas Read, "The Amalgamation of Gold-Ores," *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 37 (New York: AIME, 1907), 57; Taggart, *Handbook of Ore Dressing*, 317.
[26] These changes are noted in T. A. Rickard's discussion of milling practices at the North Star Mine in "Gold Milling in the Black Hills, South Dakota, and at Grass Valley, California," in *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 25 (1895).

Following the stamps and apron tables, the California Mill exhibited less uniformity in circuitry. Broadly considered, ore commonly underwent gravity concentration using shaking tables or vanners, with larger operations installing more comprehensive circuits, often supplemented by cyanidation. In addition to being influenced by the scale of operation, changing conditions at the mine (including fluctuations in ore composition, metal prices, technological practice, as well as company finances) could also alter milling circuits.[27] Millwrights adjusted milling performance through equipment modifications, or by the expansion, addition, or elimination of milling circuits. Mills with the same circuits could vary for other reasons. Competition between machinery makers, for instance, encouraged variation to avoid patent disputes, and small differences in equipment, such as in the spacing and positioning of riffles on a shaking table, could affect the extractive efficiency of working certain ores.

While these conditions tended to increase local variations in milling practice,[28] the California Mill did maintain a standard look. Most were "cascaded" down steep hillsides, with the milling circuit organized over several levels. The selection of side-hill sites was not simply a factor of the rugged topography in which many lode mines operated (and in which level ground was often at a premium). Mining engineers considered the monetary savings brought by the utilization of gravity in ore conveyance far outweighed the costs of mechanized or manual handling and any raised construction expenses incurred.[29]

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[27] Changes in milling performance were tracked through the comparison of daily or weekly assays of mill inputs (head), valued products (concentrate), and discard (tailings). Using a variety of formulas, extractive efficiencies for individual machines and the overall plant were ascertainable. See, for instance, Robert S. Lewis, "Milling Calculations," *Chemical and Metallurgical Engineering*, vol. 20, no. 5 (1919), 224-33.

[28] In their 1935 study of 13 small mills near Virginia City, geologists Gardner and Carpenter argued finances and millwright's decisions explained why recovery rates varied from 60% to 95%, despite the working of similar ores [noted in Arthur Taggart, *Handbook of Mineral Dressing* (New York: John Wiley & Sons, 1945), 2:71]. Differences in Californian mill practice are also described in Preston, *California Gold Mill Practices*, 66-77.

[29] The level of automation was also a point of acclaim. One engineer noted, with evident hyperbole, "Manual labor is entirely replaced by ocular labor; for superintendence, and not work, is the function of the mill-hands." James Douglas, "Summary of American Improvements and Inventions in Ore Crushing and Concentration, and in the Metallurgy of Copper, Lead, Gold, Silver, Nickel,

When the Skidoo mill was designed and erected in the early 1900s, the California Mill had been in use for over half a century. The gradual accumulation of modifications had made the California Mill by this time "a very different affair from the clumsy mills first used for crushing quartz in this State."[30] The success of this milling system was certainly proven by its widespread diffusion through western gold fields, as well as an increased foreign demand for California mill-men and milling machinery.[31] The California Mill would also meet success in working the Skidoo ore deposit, albeit it operated with some accommodation to the peculiarities of Skidoo's location.

A LIFE HISTORY OF THE SKIDOO MILL

A. Discovery and Development: The Skidoo Mines Company

In 1905, gold-bearing quartz veins were discovered on the west side of the Panamint Mountains at Harrisburg--the consequence of a rush of prospecting by "men afoot and alone, 'burro men,' carriages, wagons, and automobiles" into Death Valley after strikes in the Bullfrog District of the Amargosa Valley.[32] News of the Harrisburg discoveries attracted, among other seasoned prospectors, John Ramsey and John Thompson to the Panamint Range. Further prospecting in the vicinity proved disappointing, but in the following year, Ramsey and Thompson panned rich gold float a short distance from their camp in Emigrant Canyon. Tracing the float to a high ridge, the prospectors discovered a series of gold-bearing quartz ledges panning $82 per ton and richer. The outcroppings extended for a distance of one-and-one-half

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Aluminum, Zinc, Mercury, Antimony, and Tin," in *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 22 (1894), 338. For discussions on the suitable locations of mill sites, refer: International Correspondence Schools, *A Textbook of Metal Mining* (Scranton: International Textbook Company, 1899), 215; Taggart, *Handbook of Ore Dressing*, 1288-92; Taggart, "Seventy-five Years of Progress in Ore Dressing," 117-120.

[30] Preston, *California Gold Mill Practices*, 7.

[31] Preston, *California Gold Mill Practices*, 7.

[32] Taft, "Notes on Southern Nevada and Inyo County, California," 179. For studies of Death Valley's mining history refer Linda Greene, *Historic Resource Study: A History of Mining in Death Valley National Monument*, Part 1 (Denver: National Park Service, 1981), 609; Lingenfelter, *Death Valley and the Amargosa*.

miles, and were quickly staked out as 30 mineral claims.[33] Ramsey and Thompson suppressed news of their discovery until their "Gold Eagle" claims could be filed. In this they were marginally successful, for prospectors rushed to the strike within two months.[34]

Assays of the Gold Eagle deposit confirmed its richness and foretold tidy profits for prospectors and speculators alike. In March, Ramsey and Thompson leased the twenty-three best claims for $23,000 to George Ottis and E. Oscar Hart on a sixty-day option.[35] Hart returned to New York shortly thereafter in order to garner a sale. Unknown to Hart, over the course of a few weeks, E. A. Montgomery, owner and discoverer of Nevada's Montgomery-Shoshone Mine (the original strike of the Bullfrog district) moved aggressively to purchase the claims. Montgomery visited the property with Ottis and soon after bought Ottis's share of the option for $40,000. Montgomery then let the sixty-day option expire (disavowing Hart of any share in the mine) and purchased the claims outright. Ramsey and Thompson reputably netted $30,000 each from the deal.[36]

Montgomery appointed Matt Hoveck (former manager of the Montgomery-Shoshone Mine) and W. R. Wharton to respectively administer mine development and general finances.[37] In short order, around forty men were gainfully employed on the claims, initiating underground development and surface work.[38] Amid the development activity, the Gold Eagle property was renamed "Skidoo"--deriving from the popular phrase "twenty-three Skidoo" (equivalent to "scram"), and inspired ostensibly by the property's 23 claims.[39] In so doing, the mine joined an expanding list of unconventional place names, such as the

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[33] Original claim records are held at Inyo County, Recorder Mining Locations, Book N, 21-35; Independence. *Inyo Independent*, 16 March, 1906; *Rhyolite Herald*, 19 April, 1907; *Bullfrog Miner*, April 26, 1907. Greene, *Historical Resource Study*, 608-680.
[34] Greene, *Historic Resource Study*, 610.
[35] *Bullfrog Miner*, 20 April, 11 May, 1906; *Rhyolite Herald*, 6 April, 1906.
[36] Lingenfelter, *Death Valley and the Amargosa*, 287.
[37] Ibid.
[38] *Engineering & Mining Journal*, vol. 82, no. 11 (15 September, 1906), 511.
[39] For a discussion on the derivation of the term, refer Lingenfelter, *Death Valley and the Amargosa*, 287.

Funeral Mountains, Starvation Gulch, and Coffin Canyon, which bolstered the intrigue, and ultimately investment, in Death Valley enterprises.[40]

In April 1907, the Skidoo Mines Company formed at a capitalization of five million dollars, with Montgomery as company president and owner of 75 percent of company stock. Montgomery appointed Wharton as vice president, Hoveck as treasurer and general manager, and Charles Schwab and A. L. Davis (two financiers) as directors, and set out to make Skidoo "one of the foremost mines of the Pacific Coast."[41]

These aspirations would not be attained easily. Despite half a century of prospecting and mining, the Panamint Range boasted little in the way of transportation networks beyond foot trails and a wagon road that skirted the base of the Panamints, connecting borax operations at Furnace Creek with the town of Ballarat.[42] Skidoo was not only removed from established mining districts where supply, power, and labor needs could be satisfied, but the immediate locale was also sparsely furnished with timber and water resources. Countering these conditions would require the extensive development of infrastructure, supported by abundant finances. However, unlike the experience of most nascent companies, monies were readily available. The personal contribution of E. A. Montgomery, estimated at $550,000, enabled the company to work on several improvements simultaneously.[43]

A rapid succession of regional improvements began even before the company's official capitalization. In 1906, the Skidoo Mines had established a rudimentary communication system with the town of Rhyolite, at the heart of the Bullfrog district. Messages were transmitted by heliograph (a device for flashing the sun's rays from a mirror), with a relay station atop the Funeral Mountains.[44] This was outmoded a year later with a telegraph line to Rhyolite built by the Tucki Consolidated Telephone and Telegraph Company (formed by

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[40] Mine management apparently insisted Skidoo was "part and parcel of Death Valley," although the mines were more correctly a part of neighboring Panamint Valley. Robert Rinehart, "Mineral Prospects Around Death Valley," *Mining and Scientific Press*, vol. 97, no. 19 (29 August, 1908), 298.
[41] *Rhyolite Herald*, 19 April, 1907.
[42] Taft, "Notes on Southern Nevada and Inyo County, California," 179.
[43] Harlan Unrau, *Preliminary Historic Structure Report: Skidoo Mill/Mine, Death Valley* (National Park Service, 1998), 15.
[44] *Bullfrog Miner*, 12 April, 1907.

Montgomery).[45] Merchants in Rhyolite were also eager to increase trade with the new district and petitioned for the construction of a route over Daylight Pass in the Funeral Mountains. Generally considered, roadwork in the Death Valley region required only a small amount of clearing, although steep grades and areas of deep sands still made hauling a difficult task.[46] Work on the Rhyolite-Skidoo road began in fall 1906 from both ends and the trail, partially unfinished, was in use by 1907.[47] In this year, stages also arrived in Skidoo from Johannesberg, a town to the southwest positioned at the terminus of one of the Santa Fe lines. By 1908, a road connected the mines to Keeler (a mining district northwest of Skidoo).

The company's platting of a town site a short distance from the workings encouraged commercial development around the mines--of further benefit in reducing transportation costs, and acting doubly as an attraction to workers. Initially called Montgomery, the settlement was known for a brief time as Hoveck, until popular opinion settled on "Skidoo." The town population approached four hundred residents in 1907, making it the largest community in the Panamints. Newspaper boosterism proposed the town would soon be "a blaze of prosperity," encouraging investors that "it is those who get established first that will reap the golden reward."[48] At its peak development, realized that year, the town boasted four saloons, three restaurants, a bakery, bank (the Southern California Bank of Skidoo), post office, physician, and Death Valley's only newspaper, the *Skidoo News*. Grid-pattern streets provided an allusion of grandeur, even if the majority of structures never gained permanence beyond the tent frame.[49] Workers and managers lived on a hill southwest of the town site. In addition to the mine office, assay shed, and superintendent's residence, the company camp included

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[45] *Inyo Register*, 9 April, 1908.
[46] Clarence Waring and Emile Huguenin, "Inyo County," in *Mines and Mineral Resources of Portions of California*, Report XV of the State Mineralogist (Sacramento: Calif. State Printing Office, 1919), 42.
[47] Unrau, *Historic Structure Report*, 21-22.
[48] "Skiddoo [sic] as Feeder for the Bullfrog," *Bullfrog Miner*, 12 April, 1907.
[49] The *Skidoo News* argued the town was unlike other mining camps that "like a tin can, it lies where it is thrown." Quoted in *Inyo Register*, vol. 22, no. 46, (17 January, 1907).

a mess hall and a crib-like row of worker cabins, all of which were of timber or log construction.[50]

Incentives for other mining interests came in 1907, when the company made portions of the mineral property available for one-year lease--a system similar to that used in Nevada's Goldfield district.[51] As likely intended by the Skidoo Mines, all developments by lessees were small in scale, albeit sufficient to bring in revenue and garner more information about the composition and variability of the Skidoo ore body.[52] The company marked out lots sized 400 by 600 feet, with royalties calculated according to the ore value worked: 10 percent for ores assaying under $20 per ton; 15 percent for ore assaying from $20 to $30; and 20 percent for ores of higher value.[53] The leasing system proved popular and, within a short period, the company managed thirty leases on its property. Activities at the Skidoo property generated considerable interest by miners in the surrounding region. The California Division of Mines soon created the "Emigrant" section of the Wild Rose mining district, complete with its own deputy district recorder and voting precinct.

The crude state of regional infrastructure limited options for power supply. Although steam and diesel engines were of common use in remote regions, Skidoo Mines considered both unattractive for their dependence on regular fuel shipments. Montgomery hoped instead that the operation could be connected to electricity networks in Rhyolite and Johannesberg, but the high cost of installation meant it too was rejected. A third option, the onsite generation of hydroelectricity, was generally impractical for desert mining

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[50] Corporate paternalism did not embrace all aspects of worker's welfare and the company initially resisted the establishment of a miners union. By 1907, a Skidoo branch of the Western Federation of Miners was established, the union pledging to work cooperatively with mine development. Unrau, *Historic Structure Report*, 21.

[51] The annual length of leases is inferred in "Liberal Leasing Policy at Skidoo," *Rhyolite Herald*, 29 July, 1908. Goldfield leases were for only six months duration, but were considered important in the early development of the area's successful mines. Frederick Ransome, "Geology and Ore Deposits of Goldfield, Nevada," *U.S. Geological Survey Professional Paper 66* (Washington D.C.: GPO, 1909), 17.

[52] *Engineering & Mining Journal*, vol. 86, no. 10 (5 September, 1908), 487.

[53] This was later modified to 15 percent for ore over $20; 20 percent for ore over $30; and 25 percent for ore of higher than $50 per ton. *Rhyolite Herald*, 19 April, 1907.

operations for obvious reasons.[54] A pipeline nevertheless remained an attractive option for Skidoo, given that some system for delivering water to the site cheaply was already imperative. The Skidoo location included a few ephemeral drainages, and the company was meeting domestic needs by importing water at a cost of ten cents per gallon.[55] A year-round source was available at Emigrant Spring, five miles from the Skidoo claims, but this supply was too limited to provide for both domestic and industrial applications (estimated up to 30 miners' inches).[56] The nearest suitable supply occurred some 20 straight-line miles from Skidoo at Birch Spring, situated on the west flanks of Telescope Peak.[57] While an impressive feat, the construction of a pipeline to Birch Spring was not unprecedented. In October 1907, when the Skidoo pipeline was nearing completion, the Goldfield Consolidated Water Company in western Nevada completed a 30 mile-long pipeline made of 7-inch diameter riveted pipe, and the Florence Goldfield Mining Company was engaged in the construction of a five-and-one-half mile long pipeline to bring water to their workings.[58]

Skidoo Mines acquired the water rights to Birch Spring from Fred Gray of Ballarat in 1906. At the springs, the company constructed a four-foot by eight-foot sandbox to serve as a coarse water filter. The pipeline route was designed with minimal deviation, traversing elevations from 5,600 to 7,600 feet and gradients up to 32 degrees. Depending on the locale, the eight-inch diameter cast-iron pipes used for the line were laid in shallow open or buried trenches, or atop an earthen berm, wood-frame, or rock supports.[59]

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[54] Contemporary mining engineers also discouraged their construction for a single mine given high installation costs and often unpredictable life of an operation. See, for instance, Taggart, *Handbook of Ore Dressing*, 1316.
[55] *Engineering & Mining Journal*, vol. 85, no. 4 (25 January, 1908), 228.
[56] A miner's inch pertains to the amount of water exiting "an orifice one inch square under a head on its center of 6.5 in." [Arthur Taggart, *Handbook of Ore Dressing* (New York: John Wiley & Sons, 1927), 1602]. For California, 40 miner's inches was the equivalent of one cubic foot per second, while in Arizona, Idaho, Nevada, and Utah, one foot per second was set at 50 inches.
[57] *Rhyolite Herald*, 28 September, 1906.
[58] Ransome, "Geology and Ore Deposits of Goldfield, Nevada," 142-143.
[59] Robert Webb, John W. Steiger, and Evelyn B. Newman, "The Response of Vegetation to Disturbance in Death Valley National Monument, California," *U.S. Geological Survey Bulletin 1793* (Washington, D.C.: GPO, 1988), 26, 29.

Work began simultaneously on the construction of a full-scale milling facility. In 1907, the company contracted H. J. McCormack, a mill man from South Dakota, to design and erect a mill for the Skidoo mines. To achieve high extractive efficiency with local ores, the company submitted two tons of ore (taken as average samples of the ledges) for examination to Taylor & Co., a supplier of milling machinery based in St. Louis.[60] Upon completion of the tests, a plant guaranteed to give 85 percent recovery would be assembled and readied for shipment. Montgomery and McCormack additionally visited large milling plants throughout the local region with an eye for "adopting any device that may insure greater perfection in the plans for the home plant."[61] It is unknown what regional nuances were identified and whether any were incorporated, but the main components of the Skidoo mill certainly did not depart from the "California Mill." The mill ultimately constructed employed amalgamation, gravity concentration, and cyanidation methods, and used a familiar assortment of equipment, including jaw crushers, gravity stamps, shaking tables, and sand-leaching vats for cyanidation.

A suitable mill site was located close to mine workings at the northern edge of the property. As with the siting of many nineteenth- and early-twentieth century mills, a steep gradient, along the south side of a narrow gulch, was selected for the Skidoo mill. To facilitate construction at this locale, workers installed a steel cable across the ravine to serve as a simple hoist system.

The rapid pace of development work at Skidoo contrasted with the national economic climate facing the mining industry. In late 1907, the stock market plummeted in the panic brought by the closing of the Knickerbocker Trust in New York. Gold and silver mines soon suffered as East Coast backers withdrew from expenditure on high-risk ventures. Although mining ventures in San Bernardino and Inyo counties were not as badly affected (perhaps because gold had been recently discovered and that most work was conducted by small-

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[60] "Gigantic Mill for Skidoo Mine," *Bullfrog Miner*, vol. 2, no. 46 (22 February, 1907).

[61] Montgomery and McCormack are known to have visited plants in the Tonopah and Goldfield districts, and probably the Rhyolite and Manhattan districts as well. *Bullfrog Miner*, 8 June, 1907.

scale prospectors)[62] the financial panic may have influenced the Skidoo Mines to proceed with property development along more conservative lines. Escalating construction expenses on the pipeline brought changes to the original design and construction materials. The company scrapped plans to include tributary supply lines, and also substituted cast-iron pipes with six-to-ten-inch diameter spiral-riveted pipe in later sections of the line. Of greatest consequence, the company abandoned plans for a power plant. At its completion in 1908, the company's expenditure on the pipeline approached $250,000.[63] Water for operations was now available at the Skidoo location, but, despite the expense, the extent of its intended applications was curtailed markedly.

The milling facility was also less grandiose than initial projections. At the commencement of operations in April 1908, ten, rather than 30-40 stamps (as projected by Montgomery) were installed, and the daily capacity of the mill approached only 35 tons every 24 hours. Although milling equipment may have been pared down, the mill was designed for future enlargements. The dimensions of the building (40-feet wide by 60 feet long) could accommodate double the equipment, and the position of the mill near the top of the gulch provided ample room for the addition of other milling circuits alongside the structure or down the hillside.

The milling circuit was organized over five levels, all levels enclosed by a wood-frame superstructure sided with corrugated iron. In execution, burros pulled ore cars to the mill along a tram grade skirting the south side of the gulch. A 30-foot-long wooden trestle carried the track to the southeast corner of the mill building, where it entered the crushing circuit.[64] This circuit included a grizzly (a set of parallel, equally spaced

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[62] Indeed, prospecting continued "vigorously" along the recently completed Tonopah and Tidewater Railroad connecting Rhyolite to the Santa Fe Railroad Charles G. Yale, "California", in *Mineral Resources of the United States, 1907*, (Washington D.C.: GPO, 1908), 197.
[63] Although spiral-riveted pipe was selected as a cost-cutting measure, engineers considered this well adapted for small flows and low pressures. Furthermore, spiral riveting provided sufficient strength for the pipe to be laid directly on the ground. Taggart, *Handbook of Ore Dressing*,1277.
[64] Refer Skidoo Mill, 1907, F-2313; F-5109, DEVA Archives. Later photographs of the mill, taken directly after the mill fire, indicate the south end of the trestle began from a stone retaining wall, now used to support water tanks.

bars that acted as a preliminary sorter) and two Blake-type jaw crushers probably arranged in series. Material passing over the grizzly entered the primary (and larger) of the two crushers. Launders directed both the crusher product and ore passing through the grizzly bars, into a secondary jaw crusher. This crusher probably broke the ore to less than an inch diameter, with crushed rock dropping into the stamp ore bin at the second level. From the bin, the ore was distributed to the stamps at an even rate with the assistance of automatic feeders.

The stamps crushed the ore to a fine sand and, with the addition of mercury and water, initiated the gold recovery process. Amalgam created in the stamps adhered to copper plates attached to the bottom and back of the mortar. Ore exiting the stamps passed over apron tables, where mercury dressed copper plates also induced the formation of a gold-mercury amalgam. Three Deister concentration tables (known to be in use by 1911) were situated on the next level down and separated gold and other metals from the ore by density.[65] With the cyanide circuit still under construction, material passing over tables was discharged from the mill as tailings. Stonewalls erected across the bottom of the gulch impounded this material for future processing. During its early runs, tailrace water from the Pelton wheel was also discharged into the gulch, and some diversion system may have been installed to prevent the removal of tailings from the storage area.

As with work underground, milling work was notoriously dusty and noisy. The addition of water to the stamp batteries for amalgamation purposes helped to reduce dust production in the later crushing phases, but hearing loss undoubtedly remained a serious problem. As a minor consolation, perhaps, twelve-pane windows on the west, east, and north sides provided some ventilation and brought natural light to the working floors and upper

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[65] *Mining & Scientific Press*, vol. 102, no. 13 (1 April 1911), 478-9. The article identified the two 1,050 stamps as built by the Hendy Iron Company, and the larger stamp by the Union Iron Works. While this is counter to the stamps presently on site, the reconstruction of the mill after the 1913 fire may have brought radical changes. The upper terrace includes a sump (drained by a short section of metal pipe exiting through the retaining wall), implying its planned use for wet classification and/or concentration, where water spillage is almost unavoidable.

portions of the stamp batteries.[66] The Pelton wheel or a separate gas engine provided electrical power for illuminating the mill floors. Around six men were employed in the mill. If the apportioning of tasks followed practices at other mines, a millwright, skilled as a carpenter and machinist, probably headed the mill crew. Next in line, the head amalgamator was in immediate charge of running the mill and responsible for the collection and safekeeping of amalgam. Assistant amalgamators set stamp components, introduced mercury into the mortar at regular intervals, regulated water supply, and otherwise tended the battery. Crusher men, lowest in rank, looked after the grizzlies and rock crushers.[67] For the relatively small facility erected at Skidoo, two or three men probably worked in the mill at any given time, one worker running the crushing circuit when required, and one or two men working the amalgamation floor where copper plates from the stamps and apron tables were prepared and cleaned.[68]

Amalgam collected from the mortar box and apron plates accounted for 65 percent of the total gold recovery. By the end of June, the total cleanup was valued at $24,000. As precautions, mill cleanups were conducted at "irregular dates" and the amalgam stored in a safe at the company office. Moreover, after mine assayers had formed gold bricks from the cleanup, the bullion was "sent out by various routes."[69]

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[66] The mill building's outward appearance suggests construction as two identical sections, staggered against the hillside. On the east and west sides, each section included spaces for six windows (all 12-light sash) per side, arranged in two rows of three. "Skidoo Mill 1908," Photo Album DEVA 11262, F2313; F-5109.

[67] These observations were made by H. O. Hoffman ["Gold Milling in the Black Hills," in *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 17 (1889), 528-533] among mills in South Dakota. Larger mills also designated out positions such as foreman, machinists, and "oilers."

[68] Crushing and stamping tasks may not have been conducted simultaneously. A daily time sheet for 1909 lists only two workers in the mill, one of whom ran the cyanide circuit. Skidoo Mines Co., *Daily Record and Time Sheet, May 6, 1909*, held at DEVA Archives, Loc. 44-upper D4, Accession No. 1104, Catalog No. 15,450.

[69] "Skidoo Mill Unequal to Demands," *Bullfrog Miner*, 28 November, 1908. Louis Spaulding, an amalgamator employed at the mill, recalled cleanups were conducted approximately every two weeks [Louis Spaulding, "The Amalgamator," in George Pipkin (ed.) *Desert Sands*, vol. 4 (4), 2]. This may in fact be similar to practices at the North Star Mine, where stamp batteries were cleaned every two weeks, and the apron plates "every other day." Emile Abadie, "Gold Milling at the North Star Mine, Grass Valley, Nevada County,

The 75-ton capacity cyanide circuit began production in August.[70] Settling tanks were situated on the lower terrace of the mill structure, with additional tanks housed in an 80-foot long, gable-roofed extension on the east side of the mill.[71] The leaching tanks were arranged in parallel so that the ore could be worked in separate batches. Tailings, including those deposited during the mill's initial runs, were occasionally elevated, and possibly reground in a tube mill, for processing in the cyanide circuit.[72] In monetary terms, the cyanide plant added $2,000 in concentrates to the $5,000-10,000 recovered as bullion per month, and the plant's overall extractive efficiency improved to 90-95 percent.[73] Table concentrates (valued at $450 per ton) and those from the cyanidation circuit were shipped to the United States Smelting, Refining & Mining Co. in Midvale, Utah for final treatment.[74]

In the mines, development work now included a 330-foot-deep vertical shaft and a 1,600-foot-long tunnel.[75] The width of the veins varied considerably, from approximately two feet near the surface to reportedly as wide as 15 feet in the lower levels. Ore values ran from $12-$20 per ton. [76]

Cal.," in *Transactions of the American Institute of Mining and Metallurgical Engineers*, vol. 24 (1894), 208-220.

70 *Skidoo News* 2 May, 1908, quoted in *Inyo Register* 7 May, 1908; Charles G. Yale, "California," in *Mineral Resources of the United States, 1911* (Washington D.C.: GPO, 1912), 485.

71 "Milling Plant of Skidoo Mines Company." Photograph in *Rhyolite Herald* 1908 supplement.

72 An intention to install a tube mill (a rotating drum half-filled with ball bearings) was noted prior to the circuit's completion, and may not have seen fulfillment. Charles G. Yale "California," in *Mineral Resources of the United States, 1907* (Washington D.C.: GPO, 1908), 208]; *Mining & Scientific Press*, vol. 102, no. 13 (1 April, 1911) 478-9.

73 *Mining & Scientific Press*, vol. 101, no. 8 (20 August, 1910), 242; vol. 97, no. 21 (21 November, 1908) 685; *Engineering & Mining Journal*, vol. 86, no. 7, 345; vol. 86, no. 17 (24 October, 1908), 832.

74 *Mining & Scientific Press*, vol. 101, no. 8 (20 August, 1910), 242. In 1911, the state geological report noted Skidoo had "discontinued concentrating their ore." Charles Yale, *Mineral Resources … 1911*, 485; *Engineering & Mining Journal*, vol. 93, no. 26 (29 June, 1912), 1292. By 1912, however, the company shipped cyanide concentrates to a smelter in Selby, California.

75 Charles G. Yale, "California," in *Mineral Resources of the United States, 1908* (Washington D.C.: GPO, 1909), 334.

76 *Mining & Scientific Press*, vol. 101, no. 8 (20 August, 1910), 242; Donald Fife "Mesothermal Gold Mineralization, Skidoo-Del Norte Mines, Death Valley, Inyo County," in *California Geology*, April 1987 [reprinted from D. L. Fife

Miners worked the veins by cutting drifts and raises. Blast holes were initially drilled by single jacking and double jacking, two labor-intensive methods that pounded drill steels into the face using a sledgehammer. The company supplanted this technique at some point with compressed-air drills, which were faster than jacking and required less workers at the face. Mine workings were supported by timber stulls fashioned from locally available pinyon pine.

A surviving timesheet provides an indication of how labor was deployed about the mines for one day in 1909. On May 9, three miners conducted development work in the North-100 level, two miners labored on sinking a shaft, seven miners stoped ore from various raises, and one miner was engaged in timbering. An additional three men trammed ore and waste from the workings. These underground tasks may have been rotated, for all mineworkers received $4 per shift. Exceptions were the blacksmith, who made $5.75, and possibly mill workers, whose hours only were recorded.[77]

Perhaps as a consequence of the rapid pace of development work, the organization of underground efforts was less than desirable. By early 1909, the absence of heavy machinery had prevented the driving of crosscuts for efficient ore and waste removal. Transportation infrastructure itself was also not standardized. For the first few years, ore received at the mill had been conveyed "over five different car lines, all requiring changes of lines and changes of car, and extending [for] about a half mile."[78]

Elsewhere on the property, development on the lease lots had generated enough stockpiles of ore that the lessees petitioned Skidoo Mines for a custom milling facility. The company proposed to erect a five-stamp custom mill in the gulch below the existing mill, its position allowing the plant to use mill wastewater to power crushing machinery. Lessees would finance the

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and A. R. Brown (eds.), *Geology and Mineral Wealth of the California Desert*, Dibblee Volume (Santa Ana: South Coast Geological Society, 1980)], 89.

77 Skidoo Mines Co., *Daily Record and Time Sheet, May 6, 1909*, held at DEVA Archives, Loc. 44-upper D4, Accession No. 1104, Catalog No. 15,450. The wage scale approximated that used in the Goldfield district, Nevada, where in 1906, rates for an eight-hour day (before strikes in 1907) were $4 to $4.50 for ordinary, and $5 to $5.50 for skilled labor. Ransome, "Geology and Ore deposits of Goldfield, Nevada," 19.

78 *Rhyolite Herald*, 13 January, 1909.

mill, but Skidoo Mines Company intended to purchase the mill after four months at cost price less six percent.[79] At this time, management apparently reasserted their control over claim development by no longer renewing property leases, and with existing leases terminating in 60 days.[80] This decision was either renounced or the leasing system later reinstated, for lessees would continue to work portions of the property over the next several years. Work also continued at other locations in the Wildrose district, such as at the Cashier Mine (in the vicinity of where Ramsey and Thompson had initially prospected), although much of the fervor had passed. The emigration of rushers was certainly visible at the town of Skidoo. As early as 1908, newspapers had reported the town "has thinned out and business is poor."[81] H. W. Squires, general manager of the Skidoo mines, was more blunt in his assessment, stating "like every mining camp, the town of Skidoo is dull."[82]

The custom mill was ultimately incorporated into the existing plant. With a third stamp battery installed, the total daily output of the mill now approached 50 tons. Lessees and company ore was probably treated in alternate batches. The custom mill charged $3.50 per ton (including cyanidation), or $3 per ton if processed using waterpower. In addition, the cost of transporting ore to the mill cost lessees an estimated $2 per ton.[83] The continuing demands of the mine and lessees taxed the mill to its capacity, and the company soon installed additional cyanide tanks.[84]

From 1909 onward, the mines began turning a profit. The total cost of mining and milling for the Skidoo Mines averaged as low as seven dollars per ton (perhaps inclusive of revenues from property leases and custom milling which approximated $1,000 per month).[85] In July 1909, the mines generating

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[79] *Rhyolite Herald*, 14 October, 25 November, 1908; *Bullfrog Miner*, 28 November, 1908; *Engineering & Mining Journal* 83, no. 4 (26 January, 1907), 204.
[80] *Mining & Scientific Press*, 8 May, 1909, 653; *Engineering & Mining Journal*, vol. 87, no. 22 (29 May, 1909), 1105; *Engineering & Mining Journal*, vol. 86, no. 19 (7 November, 1908), 925.
[81] O. S. Merrill, quoted in *Rhyolite Herald* [vol. 4, no. 4, (20 May, 1908)], nevertheless assured that the "[company?] camp looks better than it has for several months."
[82] *Bullfrog Miner*, 19 September, 1908.
[83] *Bullfrog Miner*, 15 August, 1908.
[84] *Mining &Scientific Press*, vol. 101, no. 21 (19 November, 1910), 687.
[85] *Mining & Scientific Press,* July 1911, August 1911.

another $24,000, with net profits approaching $16,000.[86] In August, the mines released its first dividend of $50,000 (paid at five cents per share) to stockholders.[87] The company paid dividends over the next several years, and quickly reduced its appreciable debt to Montgomery. During these years, the Skidoo Mines ranked among the four most productive gold mining operations in Inyo County (the Wilshire-Bishop, Keane Wonder, and Reward mines), all of which were small-scale in comparison to the national industry.[88]

Skidoo's profits were perhaps not as high as anticipated, for despite the considerable effort and financial investment to counter isolation and limited local resources, these same factors still raised overheads and affected the performance of the mill. Seasonal variations in water supply meant the Pelton wheel was unreliable as a sole power source. Approximately 20 horsepower (one third of Birch Spring's projected supply) were required to run 15 stamps, with the same again necessary to power two rock crushers.[89] Water flow peaked during the summer months, and while the Pelton wheel could power the stamps and crushers at this time, for most of the year supply levels were probably insufficient to drive both circuits simultaneously. Louis Spaulding, an amalgamator employed at the Skidoo Mines in 1909 recollected that a gas engine helped run the stamps when the jaw crushers were in operation.[90] In the spring of 1912, low water flows permitted only running 10 stamps.[91] As a further accommodation to natural conditions, the cyanide circuit does not seem to have operated during the winter months on account of lowered water levels and temperatures.[92]

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[86] *Mining & Scientific Press*, vol. 99, no. 1 (3 July, 1909), 6.
[87] *Engineering & Mining Journal*, vol. 88, no. 6 (7 August, 1909), 282.
[88] Charles G. Yale, "California," in *Mineral Resources of the United States, 1909* (Washington D.C.: GPO, 1911), 275.
[89] Refer Preston, *California Gold Mill Practices*, 32.
[90] Spaulding, "The Amalgamator," 2. The gas engine was positioned below the stamp and apron level, on the concrete terrace supporting the stamp bases; *Engineering & Mining Journal*, vol. 95, no. 26 (17 May, 1913), 1023.
[91] *Engineering & Mining Journal*, vol. 93, no. 23 (8 June, 1912), 1152.
[92] During 1912 the cyanide plant was reported "closed for the winter" [*Engineering & Mining Journal*, vol. 93, no. 6 (10 February, 1912), 330-1]. This may refer to a localized or regular occurrence. Colder temperatures, however, would have decreased the circuit's overall effectiveness. The company may also have developed a system to recycle mill water to reduce short-term variations in supply.

Seasonal temperatures disrupted the hydroelectric pipeline especially, and repairs were frequent in summer and winter. The most serious instance came in early 1913, when a cold snap ruptured the pipeline in "innumerable places" and necessitated several weeks of repair work. At this time, the company discharged forty miners and shut down the mill. Mill workers used the downtime to conduct general repairs, and they may have completed the installation of two replacement rock crushers as well as the more routine replacement of copper plates in the stamp batteries.[93]

The greatest setback to mill operations followed shortly thereafter. In June 1913, a few months after the completion of repairs to the pipeline, a fire of unknown origin broke out in the mill. The blaze swept throughout all levels of the building, damaging the tram trestle irreparably and searing facing boards of a retaining wall uphill of the mill.[94] In its wake, only the extreme eastern sections of the mill complex were left unscathed. This included the eastern portion of the cyanidation plant, which still retained metal siding and roofing, and a wooden shed some 50 feet east of the mill possibly used for storage or sample testing.[95] Equipment losses were substantial, the company being able to salvage five or ten stamps and half the cyanidation tanks from the wreckage.

Despite total losses estimated at $50,000, a new plant of similar capacity was in operation by October.[96] According to Montgomery, the reconstructed facility included a "great deal of new material" to "make the mill modern." The building again comprised a five-story structure, with the three upper levels constructed of wood framing. The roofline was fitted with a step (slightly lower in the roof frame) to permit light into the stamping

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[93] *Engineering & Mining Journal*, vol. 95, no. 26 (17 May, 1913), 1023; *Inyo Register* 23 January, 1913.
[94] The stone retaining wall was located at the south end of the uppermost mill deck. Early photographs of the mill area indicate the facing boards were a later addition (see, for instance, "Skidoo Mill 1908" Photo Album DEVA 11262, and F-2313; F-5109), although visible fire damage suggests they were in place before 1913.
[95] "Skidoo After the Fire" (1913) Photo Album DEVA 11262. The survival of the wooden shed is confirmed in a ca. 1916s photograph. "Skidoo Gold Mill" by Waring, California Division of Mines and Geology, Sacramento.
[96] *Engineering & Mining Journal*, vol. 95, no. 1 (5 July, 1913), 42; 4 October, 1913, 665; *Mining World*, 4 October 1913, 611.

area, and the roof was of similar pitch.[97] The need to erect a mill quickly created some minor differences in appearance. Windows were fewer, smaller, and no longer identical in size or placement along the west and east walls. The post-fire mill accommodated ten stamps, but its narrower width (25 feet) provided no space for future expansion. Photographic evidence also indicates that former materials (such as corrugated siding and timbers) found reuse where possible.[98]

The flow sheet of the new Skidoo mill replicated the original circuit design closely. Pre and post-fire differences came generally from the reduction, rather than modernization of milling equipment. In the new mill, a 50-ton stamp ore bin, fitted with two rack and pinion gates, released ore into two automatic feeders placed immediately behind the stamps. As probably erected before, the stamps were supported by a "back-knee" frame, so termed for the extension of a sill support from the ore bin to the camshaft, above the stamp mortar.[99] A mezzanine level, situated atop the "knee" at the level of the cams enabled workers to open the ore bin gates and access the front and back sides of the stamp battery.[100] From the apron plates, ore probably passed over concentration tables before entering a classifier where sands were directed to the cyanide circuit. The cyanide plant in the new mill had a slightly reduced capacity of 50, rather than 75-tons. Burros still delivered ore cars to the mill, although instead of a tram trestle, a wide deck now extended directly back from the mill's upper floor to the tram grade. Forty-horsepower and 18-horsepower gasoline engines may have both been installed as supplemental power sources in the mill.[101]

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[97] Roof pitch determined from photographic evidence: "Skidoo Mill" (Waring, California Division of Mines and Geology, ca. 1916).

[98] Ibid.

[99] The back-knee framing method provided good overall stability, although the distance between the camshaft and driveshaft (positioned behind the stamp mortar) necessitated the use of a tightening mechanism to keep sufficient tension on the belt. In addition to increasing the wear on drive belts, the location of the driveshaft meant it was not well lighted and susceptible to water, dirt, and grease coming from the mortars. Rickard, "Gold Milling in the Black Hills, South Dakota," 911.

[100] A hoist mechanism installed above the stamps allowed workers to raise any of the stamp stems for repair work Tracks across the top of the hoist supported a "crab" mechanism which could attach to the stem.

[101] H. C. Cloudman. *State Mining Bureau Field Report, No. 174, Skidoo Mines Co.* (ca. 1913). DEVA Archives, RG#1 Archives, Cat. No. DEVA 30650, Accession No. DEVA 01240, pp. 114-5.

At the commencement of operations, the mill ran company ore for a month to clear reserves and then began processing the ore stockpiled by lessees. Milling efficiency remained high, with ore entering the mill at $15 per ton, and as little as 41 cents per ton lost in tailings.[102] Within a few months of resuming mill operations, however, assays indicated dwindling ore reserves. In early 1914, the mine superintendent considered the veins essentially worked out and predicted the closure of the mines within a couple of months. According to his estimate, only 220 tons remained in the stopes and another 500 tons on the lessees' property.[103] Montgomery decided to visit the site in person, bringing with him mining engineer J. H. Cooper for a second opinion. Upon viewing the workings, Cooper argued that the pessimistic outlook of the superintendent was the product of poor on-site management, "if not actual dishonesty on the part of the company employees in trusted positions."[104] Cooper became the new mine manager after signing a one-year contract with Montgomery. By June, Cooper had approximately forty men on the payroll and, one-month later, the Skidoo Mines Company issued a $30,000 dividend.

In contrast to the former superintendent's opinion, Cooper deemed enough ore to be present to warrant expansion of the milling circuit. Secondary reports indicate intentions to expand the mill to 60-tons daily capacity, an improvement requiring the installation of additional concentrators as well as cyanidation vats.[105] That year, the company expanded the stamp ore bin to 100-ton capacity and added a battery of five stamps (either 1050 or 1250 pounds per stamp) manufactured by Joshua Hendy Iron Works to the west side of the mill.[106] Additional Deister concentration tables and cyanide tanks were also added to the circuit. The cyanide circuit received modifications in December to enable its operation through winter. This involved the construction of a gable-roofed shed (insulated with paper

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[102] H. C. Cloudman. *State Mining Bureau Field Report, No. 174.*
[103] J. H. Cooper, "The Skidoo Gold Mines, Data Supplemental to General Report," September 9, 1928. Appended to Bell Mountain Silver Mines, Inc. Environmental Impact Report, Proposed Mining on the Del Norte Property.
[104] Cooper, "The Skidoo Gold Mines."
[105] Charles Yale, "California," in *Mineral Resources of the United States, 1914* (Washington D.C.:GPO, 1916), 376.
[106] Bin capacity calculated from field measurements, assuming a weight of pulverized quartz and pulverized sorted quartz at respectively 90 and 105 pounds per square foot (refer Taggart, *Handbook of Ore Dressing*, 1037).

and sided with corrugated iron) over the tanks, and installation of an oil-fired boiler for heating the cyanide solution. On account of continuing difficulties with the hydroelectric pipeline during the summer of 1915, the company installed another 40-horsepower gas engine to assist running the stamps. Not all improvements to milling performance were technical in nature. In April 1915, James Seymour and, upon his confession, Jeff Pervine (the amalgamator at the mill) were charged with stealing over $950 worth of gold amalgam from the mill. Intriguingly, the case resulted in no conviction on account of allegations of a bribed jury.

In retrospect, the renewal of activity at Skidoo prolonged the life of the mines for only a few more years.[107] The ore body was approaching exhaustion, and the mine's closure was accelerated by continuing problems with the pipeline, labor shortages, and perhaps as the final straw, the commencement of lawsuits. In 1915, the company came under litigation regarding their use of fraction claims legally owned by William Gray, and on which the mill site was located.[108] A previous suit filed by Gray in 1909 had failed to meet his expectations of a cash settlement. This second suit, directed against the Skidoo Mines continued use of the area, was eventually dismissed in January 1917. By this time, however, the company was essentially moribund. In the year previous, Montgomery had leased the property.[109] The Skidoo Mining Company closed permanently in September 1917. At the time of shutdown, Montgomery's operation had produced a total of 92,479.5 tons, worth $1,344,500 in gross profits.[110] With a total of $385,000 released in dividends, the mines returned approximately one third of shareholders investment. Montgomery came out ahead, although his returns are estimated as low as $60,000.[111] Following the closure, the company recouped some costs by selling equipment, including the pipeline, mine machinery, scrap iron and steel to Standard Oil Company of California for salvage. Despite his luckless court battles, William Gray retained enough enthusiasm in the future worth of the claims to purchase the mine property.

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[107] Cooper, "The Skidoo Gold Mines."
[108] Unrau, *Historic Structure Report*, 45-46.
[109] Charles G. Yale, "California," in *Mineral Resources of the United States, 1916* (Washington D.C.: GPO, 1919) 236.
[110] Cooper, "The Skidoo Gold Mines."
[111] Lingenfelter, *Death Valley and the Amargosa*, 308.

B. Depression-Era Mining and the Del Norte Years

The closure of the Skidoo Mines Company saw an end to large-scale financial investment in the ore body, but it did not conclude attempts at redevelopment. Subsequent efforts on the mining claims worked the less valuable sections of the property as well as the small ore pockets remaining in underground workings. Modest assay results confirmed that the richest portions of the Skidoo property (at least those deposits most easily accessible) had already been exploited.

The general disposition of the Skidoo property was reflective of the state of the industry in which mine operators faced a host of deleterious conditions. High labor and supply costs, elevated freight rates, war taxation, and rising labor-union activity were sufficient to suspend work altogether for many gold mines.[112] Indeed, gold production in California showed an increase for only one year (1921) in the decade 1920-1929. Annual gold production in the state reached a record low in 1929, falling below $10,000,000 for the first time since gold discoveries in 1848.[113] Gold mines in Inyo County were mostly idle throughout this period, with gold production confined to a few scattered mines in the Panamint, Funeral, and Argus mountains. Annual gold production in the county plummeted accordingly to a record low of $10,109 in 1927.

Some work nevertheless continued at Skidoo. In 1926, the Golden Glow Mine Corporation conducted prospecting and development work on the claims. Three years later, the Emigrant Springs Mining and Milling Company set out to develop the Saddlerock claims (among the initial strikes staked by Ramsey and Thompson).[114] In both cases, these operations were likely small-scale, for in

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[112] Yale, "Gold, Silver, Copper, Lead, and Zinc in California," *Mineral Resources of the United States, 1920* (Washington D.C.:GPO, 1922), 157. According to a Bureau of Mines reporter, "not only have operations been curtailed among the larger mines but many mines, large and small, have been entirely idle." Yale, "Gold. … in California*,* 1921" (Washington D.C.: GPO, 1924), 167.
[113] V. C. Heikes, "Gold, … in California," *Mineral Resources of the United States, 1929* (Washington D.C.: GPO, 1932), 434.
[114] *Inyo Independent*, 11 August, 1923.

neither case does it appear that operations were profitable, or that any substantial development work occurred.

The onset of the Great Depression created conditions that were particularly amenable to gold mining. While an increased labor pool and lowered equipment and supply costs benefited theoretically all of the mining industry, the comparatively high selling price of gold and its potential for recovery by cheap methods made gold mining especially feasible. Between 1931 and 1932, silver production in California decreased by 44 percent; lead production fell by 38 percent; and copper dropped by an astounding 91 percent.[115] By contrast, gold production in 1932 was the highest in six years and, in California, practically every gold district showed increased activity.[116] The "1932 rush" yielded negligible returns for many thousands of prospectors who tried their luck in the gold fields, but, as one official noted encouragingly, "where there is so much smoke there must surely be some fire."[117] Persistence was certainly stoked by favorable national legislation. On April 19, 1933, Congress abandoned the gold standard that had moderated gold selling prices at $26 per fine ounce, and the price of gold gradually increased. With the passing of the Gold Reserve Act in 1934, the national gold selling price was fixed at a new high of $35 per fine ounce. This act also charged the United States Treasury with purchasing all nationally produced gold and as much international gold as possible. These measures assured gold miners of a stable market and a ready buyer.[118]

Industry leaders responded by stepping up production rates, but the patches of moderate-to-high-grade gold ore remaining in mining districts also presented a prime opportunity to the small operator or mining engineer "looking for something to do."[119] In 1934, the state mineralogist reported

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115 V. C. Heikes, "California" in *Minerals Yearbook, 1932-33* (Washington D.C.: GPO, 1933), 121.
116 Walter Bradley, "Renewed Activity in California Gold Mining," 1932, reprinted from *Mining and Metallurgy*, 3.
117 Bradley, "Renewed Activity," 7. Also refer Charles Miller, *The Automobile Gold Rushes and Depression Era Mining* (Moscow, Idaho: Univ. of Idaho Press 1998); Charles Merrill and Charles Henderson, *Small-Scale Placer Mines as a Source of Gold, Employment and Livelihood in 1935* (Philadelphia, 1937).
118 Chas. Henderson, "Gold and Silver," in *Minerals Yearbook, 1934, Part II: Metals* (Washington D.C.:GPO, 1934), 25-34.
119 R. C. Fleming, "A One-Man Gold Mine," *Mining and Metallurgy*, vol. 13 (1932), 85.

that 49 lode mines in California had each produced more than 1,000 ounces of gold during the year. In fact, this accounted for only five percent of all known lode-gold operations in the state.[120]

In Inyo County, lode mining resumed at the sites of many formerly productive gold mines. Operations employed from one to 10 workers, with the sole exception of the Cardinal Gold Mining Company on the east slope of the Sierra Nevada, where 105 men were listed on the payroll.[121] The revival of gold mining saw an increased variation in milling practice. In Inyo County, ball mills and rolls were just as popular as gravity stamps for ore crushing, and Chilean mills and arrastras (in which ore was ground in a circular trough by heavy boulders) were also in use by smaller operators. A few mills supplemented amalgamation and/or cyandiation circuits with flotation methods.[122]

Mining interests in Death Valley were aided by the formation of the Death Valley National Monument in February 1933. Intending to foster "legitimate prospecting or mining activities" the Department of the Interior extended mining laws to the monument in June, making it open to prospecting, location, entry, and patent.[123] Of further benefit, the formation of the monument brought the construction of new roads and trails, actions that diminished some of the high transportation costs faced by operators earlier in the century. Indeed, savings made by truck transportation enabled operators at the Cashier, Chloride Cliff, and Golden Treasure mines to forgo onsite milling entirely.[124]

By 1935, mining interests had returned to Skidoo. In that year, the Gray and Worcester Mining Company set out to develop the Skidoo property (now renamed Silver Ball), employing 16 men in development work.[125] The operations

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[120] F. W. Horton and H. M. Gaylord, "Gold, Silver, Copper, Lead, and Zinc in California," *Minerals Yearbook 1935* (Washington D.C.: GPO, 1935).
[121] W. B. Tucker and R. J. Sampson, "Mineral Resources of Inyo County," in State Mineralogist's Report 34, *California Journal of Mines and Geology*, vol. 34, no. 4 (October 1938).
[122] Tucker and Sampson, "Mineral Resources of Inyo County."
[123] Anon. "Death Valley National Monument is Now Open to Mining." *Report 30 of the State Mineralogist*, vol. 30, no. 4 (Sacramento, 1934), 444-5.
[124] Tucker and Sampson, "Mineral Resources of Inyo County" (1938).
[125] Greene, *Historic Resource Study*, 676.

removed ore averaging $30 per ton (on account of new gold prices), processing the ore either in the Skidoo mill or at the Journagin mill, a 25-ton cyanidation plant located a short distance away in Emigrant Canyon. In 1937, the Journagin Mining and Milling Company secured a lease on the Skidoo property and continued development work.[126]

Mining activity in the vicinity of the Skidoo claims also yielded promising results. In 1936, prospectors identified a sizable body of low-grade ore a short distance northwest of the Skidoo workings. After staking the ore body with six claims, the owners, J. P. McCafferty, L. V. Howell, and James Stewart, leased the "Del Norte" property to Adolph Ramish and Roy Troeger, respectively president and manager of the Panamint Milling Company.[127]

In 1939, Troeger purchased the entire Skidoo property including the Del Norte and Skidoo claims and mill site, and leased the mines to Morris Albertoli and John Rogers. Encouraged by their findings, the lessees formed the Del Norte Mining Company. Low-grade ore was treated at the company's mill in Mojave, while ore averaging $30 per ton was treated at the Skidoo mill. Although it would not be realized, Troeger pushed for the reconstruction of the partially-salvaged Skidoo pipeline to supply water again to the Skidoo Mill, and also for a 300-ton facility he proposed to site near the Del Norte workings.[128]

The Skidoo mill's revival necessitated modifications to make the facility accessible by motor vehicles. Bulldozers graded a road from the former tram grade to the ridgeline above and up-slope of the mill building.[129] Here, the company erected a primary ore bin and unloading deck so that trucks could dump ore directly into the milling circuit. The ore bin held 50 tons of ore, and was fitted with three compartments, each emptied by a rack and

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[126] California State Mining Bureau, *Report of the State Mineralogist, 1937-1938*, 474.
[127] Tucker and Sampson, "Mineral Resources of Inyo County" (1938).
[128] Greene, *Historic Resource Study*, 678.
[129] This assessment is based on a mill photograph (Hild 620, Eastern California Museum Collection).

pinion gate.[130] The primary crushing area, complete with grizzly, jaw crusher, and ore conveyor, was repositioned beside the bin. Ore released from the gates dropped down a concrete-lined chute onto grizzly bars, spaced approximately one-and-three-quarter inches apart.[131] Oversize passed over the bars and dropped into the mouth of a Llewellyn Iron Works crusher of the Blake (jaw)-type. A metal chute welded to the base of the crusher directed grizzly undersize and crusher product onto an ore conveyor.[132]

The conveyor transported ore 50 feet to the mill building and into a secondary crusher. Here, ore was broken to one-quarter-inch size and distributed to the stamp bins by a simple gravity feed system.[133] Woven-wire screens of 16-mesh fitted to the front of the stamp mortar allowed particles sized 0.03 inches diameter or smaller to pass onto the apron plates.[134]

A trough set at the end of the aprons, directed ore into a chain-drag classifier at the next level. As before, sands were conveyed to the cyanidation circuit, and slimes were discarded without further treatment. The cyanide tanks, 14 feet in diameter and five-feet high (probably those installed in the post-fire mill), were constructed of corrugated iron lined with concrete to prevent corrosion. The tanks were fitted "false bottoms" comprised of a wooden trellis that supported a filter cloth. The tanks were

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[130] Field measurements indicate the bin held 1,200 cubic feet. Ore tonnage was calculated at 90 pounds per square foot--an approximate weight for pulverized, loose quartz (refer Taggart, *Handbook of Ore Dressing*, 1037). The separation of the bin into compartments may have been of application for custom milling, as well as enabling ore of an average grade to be delivered to the mill. It is possible that the bin was salvaged from a local milling plant. The trapezoidal shape of the bin is conspicuously similar to that used in Journigan's mill located in Emigrant Canyon, where Skidoo ore had been processed earlier.

[131] This approximation is based on the jaw opening of the primary crusher.

[132] Field recording indicates a canvas strap was also attached to base of the chute prevented ore spillage over the conveyor belt. The motor used for powering the crusher and conveyor was probably housed atop a wooden crib that paralleled the conveyor bed.

[133] This consisted of two conduits attached to the base of separate hoppers.

[134] A summary of mill operations circa 1941 was published ten years later in "Mines and Mineral Resources of Inyo County" by the State of California Mining Bureau [*California Journal of Mines & Geology*, vol. 47, no. 1 (January 1951), 51]. The description notes "Ore was hauled by truck to a 50-ton ore bin, crushed to ¼-inch size by two jaw crushers in series, reduced to 16-mesh by stamps, and the coarse gold concentrated and removed. The pulp was then

partially cantilevered over stone retaining walls, and directly atop a notch cut into the top of the retaining wall that allowed a tank hatch to be opened for waste removal. An overflow pipe, issuing from a trough attached to the lip of the tank joined the pipe draining the "pregnant" (gold-bearing) solution from the tank bottom. From here the solution passed into a four-inch diameter conduit that conveyed the solution from all tanks to zinc boxes for processing.[135]

In the absence of a reconstructed pipeline, gas engines presumably powered the mill. Water for operations was trucked in from Emigrant Spring and dumped into large tanks set on the former tram-grade close to the mill building.

At the close of 1940, the company had reportedly mined 3,723 tons of ore averaging $30 per ton, with an additional 7,000 tons of ore processed in the Del Norte Mill at Mojave over the previous eighteen months.[136] Despite a promising start, mining and milling operations would cease within two years, largely on account of the reversal of those economic conditions that had encouraged gold mining in the early-to-mid 1930s. Under wartime conditions, mines faced inflated equipment costs and decreased labor availability. Most critically, government legislation targeted gold mining specifically as a nonessential wartime industry. In November 1941, the passing of Preference Rating Order P-56 gave concessions to operations involved in the mining of strategic resources (such as copper). Del Norte closed the Skidoo Mill by August 1942 "due to [a] shortage of supplies."[137] Two months later, the War Production Board passed Limitation Order L-208, requiring gold mines to cease new development within one month, and terminate all operations within sixty days unless issued a permit to continue operations. Mines producing less than 100 tons of gold per month were technically exempt from the order, but the wartime conditions generally discouraged their continuance. According to additional wartime legislation, gold miners of working age and full health

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thickened, the slimes going to waste and the sands (about three-fifths of the total) leached."

[135] The classifier raked sands into to a hopper partly suspended over tram tracks. Workers pushed a tramcar beneath the hopper and opened the gate manually. Once in the tramcars the sands were dumped into the leaching tanks.

[136] The low-grade ore tonnage accounts for ore taken from Del Norte, Gold King, and other local mines. Greene, *Historic Resource Study*, 679.

[137] *Inyo Independent*, vol. 72, no. 7 (7 August 1942), 6.

had to be assigned to other nonferrous mining jobs.[138] The following year, gold production in Inyo County fell 63 percent (slightly better, in fact, than California as a whole where the decrease exceeded 80 percent).[139] By 1944, the only national gold output came as a byproduct of base-metal mining.

The Limitation Order was rescinded in 1945, but economic conditions for gold mining were slow to improve. While gold prices remained at $35 per fine ounce, mining companies faced a burgeoning post-war economy that improved employment opportunities and increased wage rates. Roy Troeger held ownership of the Skidoo property throughout the post-war period. Despite the depressed economic conditions for gold mining, Troeger retained confidence in the possibility of future development and maintained a right of way along the pipeline should mining conditions improve to warrant its rehabilitation. However, maintenance of existing structures was not a priority. By the late 1950s, the only standing structures consisted of a few ore bins and an increasingly dilapidated mill building.[140] In addition to a progressive loss of siding, timbers supporting the northwest corner of the mill had failed. A mishap within the mill (seemingly from a botched milling attempt) delivered the *coup de grâce* by flooding stamp sands across the lower tiers of the facility and out the sides of the building. In some places the sands engulfed the cyanide tanks entirely.[141]

Although there was little hope of resuscitating the mill, the Skidoo ore deposits continued to attract miners for several more years. The rise in the selling price of gold through the 1970s renewed interest in gold properties nationally, and the Skidoo location soon witnessed another string of prospecting efforts. That year, Troeger leased the Del Norte claims north of the mill gulch to Mineral Associates, and in 1971, the claims were sold to

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[138] Staff, Bureau of Mines. *An Assessment of Factors Affecting Small Mining and Custom Milling and Smelting Operations in the Western United States* (Washington: GPO, 1982), 81.
[139] Production figures in terms of monetary value. Statistics derive from William B. Clark, "Gold Districts of California," 4; L. A. Norman, Jr., and Richard M. Stewart. "Mines and Mineral Resources of Inyo County," *California Journal of Mines and Geology*, vol. 47, no. 1, (San Francisco, Division of Mines, 1951).
[140] L. Burr Beldon, *Death Valley Historical Report* (1959), Manuscript on file at DEVA, X-15.
[141] Charles B. Canby, "Skidoo Mine April 1953" (photograph). Copy in DEVA archives, Skidoo Report Files, Accession No. 2082, photo 20.

Bell Mountain Silver Mines, a subsidiary of Petro-Mineral Projects Inc. For the next few years, the company engaged in systematically sampling the Skidoo and Del Norte claims, work that resulted in the digging of 30 shafts and seven open cuts within a four-acre area.[142] Some high-grade ore was also mined for use in gold panning at the Knotts Berry Farm amusement park in Buena Park, California.

In 1974, Bell Mountain Silver Mines joined with the Coso Corporation to begin a program of drilling work on the property. The following year, with gold prices approaching $162 per fine ounce, Petro-Mineral Projects set out to process ores on the Del Norte claims by the relatively new method of heap leaching. This modification of the cyanidation process involved the percolation of weak cyanide solutions through coarsely crushed ore placed on a prepared, impervious surface. Channels directed pregnant solution running off the pile into holding ponds for further processing (the gold typically extracted using zinc dust or carbon as a precipitant). The low cost of this process made heap leaching an effective way to exploit low-grade ores, mine waste, or ore bodies too small to warrant the construction of a mill.[143]

The company prepared a heap leaching site a short distance from the workings, laying a neoprene apron and stacking approximately 5,000 tons of ore (of a proposed 10,000 tons) by 1976. In that year, however, the passing of Public Law 94-429 suspended all further development on mining properties in National Park Service lands until approved by validity examinations. Mining operations did not resume, and the first batch of ore readied for heap leaching would be left as a neat, truncated pyramid, a comparatively simple and altogether different California Mill.[144]

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[142] Unrau, *Historic Structure Report*, 55.

[143] H. J. Heinen, D. G. Peterson, and R. E. Lindstrom, "Processing Gold Ores Using Heap Leach-Carbon Adsorption Methods," *U.S. Bureau of Mines Information Circular 8770* (Washington D.C.:GPO, 1978), 2, 7.

[144] The Skidoo Mill and other mine equipment remained in the hands of the Roy C. Troeger Trust until its donation to the National Park Service in 1993. The National Park Service immediately began emergency stabilization on the mill. For detailed accounts of the transfer of ownership, general deterioration of the mill, and stabilization efforts refer: Memorandum from Robert Higgins, Chief, Energy, Mineral Resources Branch to Regional Director, Western Region, 8 January, 1987; Edwin L. Rothfuss, Superintendent, to Carl Dresselhaus, 29 August, 1984; Edwin Rothfuss to Virginia Troeger. 22 October, 1984. (Skidoo Box); Edwin Rothfuss to Mrs. Clyde E. Shields, 27 May, 1992. DEVA Mining Files, L3023, Bul-L Box 2 of 2, Del Norte-Angst folder; Jan Lawson, DEVA

MILLING TRADITIONS AND MINING TRANSFORMATIONS

The history of ore processing on the Skidoo and Del Norte claims can be viewed as a parable to changing industrial practices from the late-nineteenth century to mid-twentieth century. Within this period, leading metal mines in the United States shifted attention to low-grade ores in response to the general depletion of high-grade deposits. Changes occurred first in the mining of base metals (such as iron and copper), where the employment of capital-intensive technologies and concomitant de-skilling of labor heralded the mechanization of mine work, and the winning of greater profit margins.[145]

In the gold mining industry, such transformations marked the decline of gravity stamping from ore dressing practice. As lode-gold mines worked more complex and lower-grade deposits, the recovery techniques of flotation and cyanidation acquired greater usefulness than amalgamation and gravity concentration. While engineers increasingly opted in favor of designing either all-flotation or cyanidation circuits, this did not itself preclude the use of gravity stamping for crushing. Rather, the most direct blow to the gravity stamp came from improvements to the cyanidation process that enabled it to work with slimes previously discarded from mills.[146] Slime cyandiation circuits had greater extractive efficiency than the leaching of sands (in that the gold was more easily dissolved), and millwrights soon modified crushing circuits to emphasize the output of fines. As a producer of coarse sands, gravity stamps were relegated to the service of intermediate crushing.

Archaeologist, Memorandum to Chief Resources Division, DEVA, 22 August 1990, 2; Benjamin Levy, *Death Valley National Monument Historical Background Study*, Office of Archeology and Historic Preservation (1969), 153; Thomas Mulhern, *Skidoo Stamp Mill, Death Valley National Monument, December 6, 1977* (U.S. Department of the Interior, National Park Service, Western Region), on file at DEVA; Mel Essington, Jan Lawson, and Chris Thompson, *Death Valley National Monument, Skidoo Mill Emergency Stabilization Project Report, November 1993*. Report on file in DEVA library stacks.

[145] Harold Barger and Sam Schurr, *The Mining Industries, 1899-1939: A Study of Output, Employment, and Productivity* (New York: National Bureau of Economic Research, 1944); Logan Hovis and Jeremy Mouat "Mining Engineers and the Transformation of Work, 1880-1930," in *Technology and Culture*, vol. 37, no. 3 (1996), 429-456.

[146] Slime cyanidation was made possible largely through the addition of pulp thickening devices, such as the Dorr Thickener.

Yet, in this capacity, gravity stamps now competed with a range of other crushing technologies (such as ball mills, roll crushers, and cone crushers), capable of better size reduction ratios and greater daily tonnage. By the 1930s, few mills installed gravity stamps in their circuits, and the progress-minded mining engineer considered their use "vestigial."[147]

With the abandonment of the gravity stamp, the "California Gold Mill" lost its usage as a signifier of current practice. The stamp had been the common denominator, and no other singular technology replaced its absence. Milling practices in California, like the ore bodies exploited, became ever more diverse.

Instead of disappearing from the mining landscape, the California Mill found continuing use among a number of small-scale operators during the Depression Era. This perseverance is partly attributable to small enterprises (Skidoo included) reworking formerly productive mines where a sizable amount of equipment and infrastructure could be reused. Amalgamation was also favorable in comparison to flotation and cyanidation methods, since it took fewer man-hours and could be run by less-skilled operators--of especial benefit to smaller operations where labor tended to be limited and less task-specialized.[148] From a technical perspective too, large-scale industry had abandoned the gravity stamp due to changes in the ores worked rather than improvements in technological efficiency. Small-scale mines, by contrast, continued to work free-gold ore pockets, in which gravity stamping and amalgamation could still recover the bulk of gold.[149] Consequently, gravity

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[147] Robert Richards and Charles Locke, *Textbook of Ore Dressing* (New York: McGraw-Hill, 1940), 66; Taggart, "Seventy-five Years of Progress in Ore Dressing," 90, 95. Bureau of Mines geologists Charles Jackson and John Hedges noted in 1938 that, in comparison to other crushers, "The stamp mill is not an efficient crushing machine, although it has been retained in a number of mills, some of them quite large, probably owing to the fact that the investment had been made or to the peculiar crushing characteristics of the ores." Jackson and Hedges, *Metal-Mining Practice*, 395.

[148] Gardner and Johnson, "Mining and Milling," 20-21. Perhaps for these reasons, 1, 3, and 5-stamp batteries also remained popular as a cheap technology for prospecting work.

[149] Stamps were so effective, in fact, that even into the late 1950s gravity stamps were considered "unexcelled" as machines in which amalgamation and crushing were conducted simultaneously. Taggart, *Handbook of Mineral Dressing*, 4: 87.

stamps remained an effective technology for smaller operations and where the cost of replacement was uneconomic.[150]

The survival of mill equipment at Skidoo permits some insight into the performance of the California Mill in its later years. As can be anticipated in the span of any operation, milling equipment at Skidoo shows signs of wear and tear. Reduction is seen on most stamp components,[151] while repair work is visible on the primary jaw breaker, where a welded iron strip reinforces an edge of the crusher mouth that had sheared off. The automatic feeder for the middle battery appears to be a replacement. Not only does the mechanism use slightly different operative mechanics than its neighbors, but a broken feeder lies close by, dumped unceremoniously beside the driveshaft and partially buried in stamp sands.[152]

Less expectedly, the arrangements of cams on the stamp camshaft show some departures from conventional, or at least, as-manufactured practice. In the design of gravity stamps, stamp cams were left or right "handed," the difference determined by the side of the stem raised by the cam arm, if observed from the back of the battery, and with the upper arm of the cam turning away from the observer. While handedness had no affect on functionality, the motion of lifting the stem stressed the battery frame in the same direction as a cam's "hand." To prevent a 10-stamp battery from shaking itself apart, standard practice configured the cams to direct tension toward the shared center post. Thus, with our observer placed behind the

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[150] Refer E. D. Gardner and C. H. Johnson, "Mining and Milling Practices at Small Gold Mines," *U.S. Bureau of Mines Information Circular 6800* (Washington D. C.:GPO, 1934).

[151] In the stamp mortar box, for instance, stamp shoes and bosses making up the stamp "head" show considerable reduction. Some tappets fixed to the stamp stem are worn on both upper and lower lips, indicating they were flipped at some point. (Flipping the tappet enabled the cam arms to lift the stem to its maximum intended drop height.) For a general discussion of wear rates of stamp components, refer Taggart, *Handbook of Ore Dressing*, 323-31.

[152] The Challenge-type feeder, present for the western and eastern batteries, distributed ore into the mortar from a rotating plate. (The action was made automatic by the extension of a brace to the middle stamp stem. A collar attached to the stem hit the brace as the stamp raised and lowered, and the jarring effect triggered a clutch mechanism on the feeder that rotated the plate by a fraction.) The feeder installed at the middle battery was triggered similarly, but it regulated ore flow through the jolting up-and-down motion of a fixed bottom plate. The feeders also differ in material

stamps, the right battery would normally be fitted with all left-handed, and the left battery with all right-handed cams. The ten-stamp frame at Skidoo conforms to these principles, except for the arrangement of the right battery, which is fitted with three left- and two right-handed cams--a less-than-ideal replacement suggestive of a lack of "proper" parts.

Stamp drop orders also show minor variation. The larger Hendy stamp adopts the California pattern (1, 4, 2, 3, 5), but the Union Iron Works battery does not conform with the equivalent 10-stamp sequence.[153] Configuring the stamps as two five-stamp batteries, the westernmost battery uses a reverse of the Homestake pattern (1, 4, 2, 5, 3), and the easternmost (1, 3, 4, 2, 5) a reverse of an alternate to the California sequence 1, 5, 3, 2, 4.[154] If, as millwrights contended, drop orders worked differently for different ores, the use of multiple patterns was not beneficial to maximizing extractive efficiency. However, while drop patterns differ, each battery probably yielded an acceptable level of performance since all drop sequences matched common patterns or their derivations. It is also questionable whether the savings or losses to efficiency between these patterns amounted to much of an economic difference to the small-scale operator treating limited volumes of material.

These subtle departures from textbook arrangements, such as in the selection of cams, suggest a general pragmatism in the use of materials on hand to solve the majority of problems--a practice that may have always prevailed. Differences in stamp drop order and the discard of broken machinery within the mill (as seen with the automatic feeder) imply an

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construction, the outer two comprised of cast iron, and the center feeder made using galvanized iron.

[153] By 1904, Union Iron Works standard for 10 stamp frames was 1, 7, 3, 9, 5, 2, 8, 4, 10, 6, reading from left to right and from the feed side (a change from 1, 5, 9, 7, 3, 2, 6, 10, 8, 4, used in 1896). Union Iron Works, *The California Stamp Mill* (Company catalogs, 1896, ca. 1904), Bancroft Archives, Berkeley.

[154] Reverse sequences are formed by re-labeling stamps from the opposite end (i.e., 1, 2, 3, 4, 5 becomes 5, 4, 3, 2, 1) and, beginning with the new "1", following the pattern to the right. Thus the California pattern 1, 4, 2, 3, 5, is relabeled 5, 2, 4, 3, 1 and becomes the reverse pattern 1, 5, 2, 4, 3; the Homestake pattern 1, 3, 5, 2, 4, is relabeled 5, 3, 1, 4, 2, and becomes 1, 4, 2, 5, 3. Although one textbook listed the 1, 3, 4, 2, 5 sequence as a reverse of the California pattern [S. J. Truscott, *Text-Book of Ore Dressing*

overriding concern with the functionality of the circuit rather than its precision and orderliness. This supports a notion that the continued use of gravity stamps by small mines was primarily one of convenience. Small operations may have employed some "traditional" technologies, but the history of milling practice at Skidoo also shows the influence of contemporary conditions. Del Norte updated the mill to permit ore delivery by dump trucks, a modification that did not alter equipment or the order of the circuit. The proposal for a 300-ton milling plant in the 1930s, and the actual installment of a heap leaching facility on the Del Norte claims in the 1970s are also telling. Small mines were not only actively incorporating new technologies, but also expanding their repertoire to include lower-grade ores.

CONCLUSION

The history of Skidoo illustrates the spectrum of gold mining activity occurring in the Death Valley region, from the activities of well-funded operations to those of small-scale prospecting and development. While the scale and output of the Skidoo Mines pales in comparison to leading operations elsewhere in California and Nevada, the small-scale nature of activity represents the type of enterprise that numerically dominated California's gold fields from the nineteenth to mid-twentieth centuries.

When the Skidoo mill began operation in 1908, hard-rock mining in the western United States was a well-established industry. In California, the working of lode-gold deposits had increased steadily since the discovery rushes of the mid-nineteenth century and, by the turn of the twentieth century, was evident to some extent in every county in the state. These five decades of activity saw the establishment of regional infrastructure and mine supply networks throughout much of California. It had also witnessed the creation and widespread dissemination of a technical system for processing ores effectively. In outward appearance as in internal organization, milling at Skidoo followed the model of the California Gold Mill.

(London: MacMillan and Co., 1923), 152] this is an error caused by reading the inverted sequence to the left.

The Skidoo mill operated intermittently over a 40-year period, processing ores by amalgamation, gravity concentration, and cyanidation. Despite its near total destruction by fire in 1913, the mill would see little departure from its original design and circuitry, even during its reuse in the Depression Era. The most significant alterations occurred during the sixty-year period of abandonment. The force of gravity, formerly harnessed for the conveyance of ore, has in the absence of a millwright, conveyed much of the mill's superstructure down-slope. The building is now without roof and most walls, but the site still preserves nearly all equipment, conveyance systems, and mill floors *in situ*. Aridity and isolation, the two factors that historically aggravated operations, have, by contrast, benefited historical preservation. Despite a skeletal appearance, the Skidoo mill retains considerable dignity as a seldom-seen technology once ubiquitous in the gold mining landscapes of the West.

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